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**Results of the  
Preliminary Radiological  
Survey at the Former  
Diamond Magnesium  
Company Site,  
Luckey, Ohio (DML001)**

**R. D. Foley  
J. W. Crutcher**

**OPERATED BY  
MARTIN MARIETTA ENERGY SYSTEMS, INC.  
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DEPARTMENT OF ENERGY**

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**HEALTH AND SAFETY RESEARCH DIVISION**

**Nuclear and Chemical Waste Programs  
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**RESULTS OF THE PRELIMINARY RADIOLOGICAL SURVEY  
AT THE FORMER DIAMOND MAGNESIUM COMPANY SITE,  
LUCKEY, OHIO (DML001)**

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## ABSTRACT

As part of the Formerly Utilized Sites Remedial Action Program (FUSRAP), the U.S. Department of Energy (DOE) is implementing a radiological survey program to determine the radiological conditions at sites that were used by the department's predecessor agencies. One such site is the former Diamond Magnesium Company facility in Luckey, Ohio. The preliminary radiological survey discussed in this report was conducted at the request of DOE by members of the Measurement Applications and Development group of Oak Ridge National Laboratory in December 1988.

The former Diamond Magnesium Company site in Luckey, Ohio, was used as a magnesium reduction plant during World World II. It was closed in 1945 and reopened in 1949 as a beryllium production facility, operated by Brush Wellman for the U.S. Atomic Energy Commission. The preliminary radiological survey included (1) a surface gamma scan of part of the property outdoors, (2) collection of surface and subsurface soil samples, and (3) collection of water samples. Laboratory analysis of soil samples showed concentrations of  $^{226}\text{Ra}$  in excess of applicable DOE guidelines. A follow-up, detailed survey is recommended.

# RESULTS OF THE PRELIMINARY RADIOLOGICAL SURVEY AT THE FORMER DIAMOND MAGNESIUM COMPANY SITE, LUCKEY, OHIO (DML001)\*

## INTRODUCTION

The magnesium reduction and beryllium production facility in Luckey, Ohio, referred to in this report as the former Diamond Magnesium Company site, was operated during World War II as a magnesium reduction plant. The plant was closed in 1945. Following destruction by fire of the privately owned Brush Beryllium Company production plant in Lorain, Ohio, the U.S. Atomic Energy Commission (AEC) contracted with Brush Wellman to design and manage a beryllium production facility. The former Diamond Magnesium Company site was chosen, and it was operated by Brush Wellman for the AEC from 1949 to 1958.<sup>1</sup>

Records indicate that in late 1951 the AEC shipped approximately one thousand tons of scrap steel, contaminated by fission products, yellow salt, and concrete flooring, to the former Diamond Magnesium Company site for use in the processing of magnesium.<sup>2</sup> The primary contamination in this scrap metal was the yellow salt, which was sodium uranates and uranium oxides.

During the period of Brush Wellman operation, when the plant was converted to a beryllium extraction and production plant, ore containing beryllium was processed to obtain beryllium pebbles, which were shipped to other facilities for further processing and machining. The processing of beryllium ore to produce vacuum cast billets and beryllium oxide created waste solutions and precipitated sludges that were impounded in lagoons. All lagoons were of shallow construction, approximately 1.2 m (4 ft) deep, and were formed by scraping the top layer of soil and constructing dikes. Reportedly, the lagoon liner was compacted clay. Excess wastewater accumulated in the lagoons and, in accordance with Ohio Water Pollution Control Agency regulations, was discharged to the Toussaint Creek. As a lagoon section filled with sludge, additional ones were added. Lagoons A, B, and C (Fig. 1) were constructed and used for impoundment. Lagoon D was constructed in 1956 but was never used.<sup>1</sup>

When the Luckey plant was closed in 1959, an 8.5-acre, dike-enclosed landfill was constructed at the northeast corner of the property, and, reportedly, the hazardous sludge and contaminated soil located in Lagoons A, B, and C were moved to that landfill. The

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\*The survey was performed by members of the Measurement Applications and Development Group of the Health and Safety Research Division at Oak Ridge National Laboratory under DOE contract DE-AC05-84OR21400.

plant closure plan specified leveling the dikes on the empty lagoons and filling the lagoons with sufficient clay to bring the areas to ground level. The 8.5-acre landfill area was then capped, graded, and seeded. The facility was included in a 1961 sale of property by the General Services Administration to Aluminum and Magnesium, Inc., a division of Vulcan Materials Company. In 1968 Goodyear Tire and Rubber Company acquired the property. The site is currently owned by Motor Wheel Corporation (MWC).

As part of the Formerly Utilized Sites Remedial Action Program (FUSRAP), the U.S. Department of Energy (DOE) is implementing a radiological survey program to determine the radiological conditions at sites that were used by or adversely impacted by the department's predecessor agencies. One such site is the former Diamond Magnesium facility in Luckey, Ohio. The preliminary radiological survey discussed in this report is part of the FUSRAP effort and was conducted at the request of DOE by members of the Measurement Applications and Development group of Oak Ridge National Laboratory (ORNL).

A preliminary radiological survey of the commercial property known as the former Diamond Magnesium Company site, 21200 Luckey Road, Luckey, Ohio, was conducted during 1988. The survey, sampling of water, and sampling of the ground surface and subsurface were carried out on December 6 and 7, 1988.

### Site Description

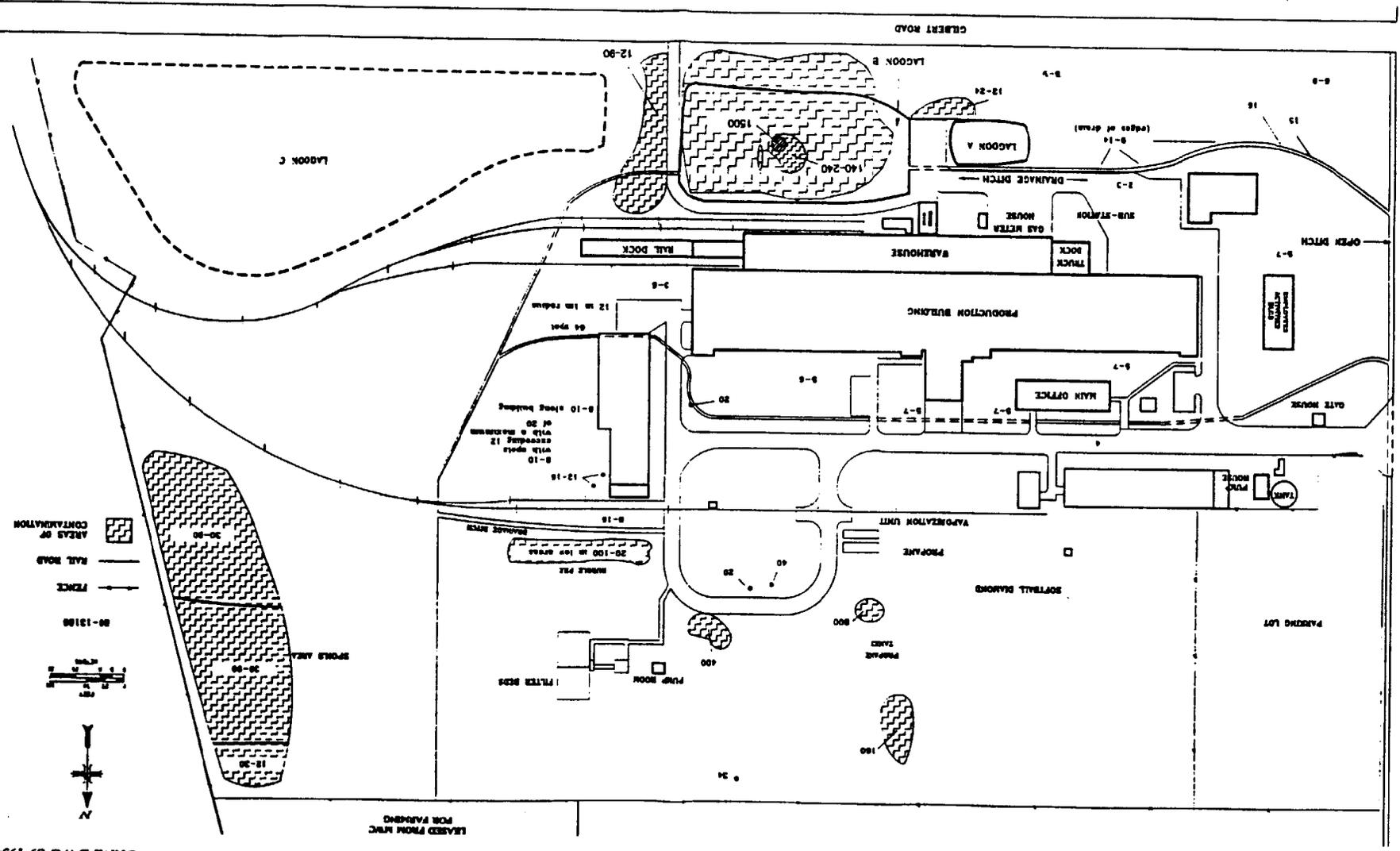
The former Diamond Magnesium Company site, which covers approximately 40 acres, lies in a generally L-shaped configuration and is located one mile north of Luckey, Ohio, approximately 22 miles southeast of Toledo on State Route 583. The plant is bounded on the east by the New York Central Railroad and on the north by Toussaint Creek. For the most part, the area surrounding the site is open farm land, with quarries located south of the site.

The lagoons that held the facility's waste solutions and precipitated sludge are shown in Fig. 1. At the time of this preliminary radiological survey, Lagoons A and B appeared not to have been dredged or backfilled to ground level as indicated in the closure plan. Analysis of soil samples taken at depths of 0 to ~105 cm (0 to 42 in.) in Lagoon C (locations shown on Fig. 2) indicates that Lagoon C was covered with a layer of approximately 60 cm (24 in.) of soil but was not excavated to remove sludge and contaminated soil prior to the addition of the layer of soil. Photographs representative of the site at the time of this survey (December 1988) and of Lagoon B prior to draining appear as Figs. 3-8.

### SURVEY METHODS

The radiological survey included (1) a gamma scan at the surface of a large portion of the property outdoors, (2) collection of surface and subsurface soil samples, and (3) collection of water samples.

Fig. 1. Gamma radiation levels ( $\mu\text{R/h}$ ) measured on the surface at the former Diamond Magnesium Company site, Lucky, Ohio (DML001).



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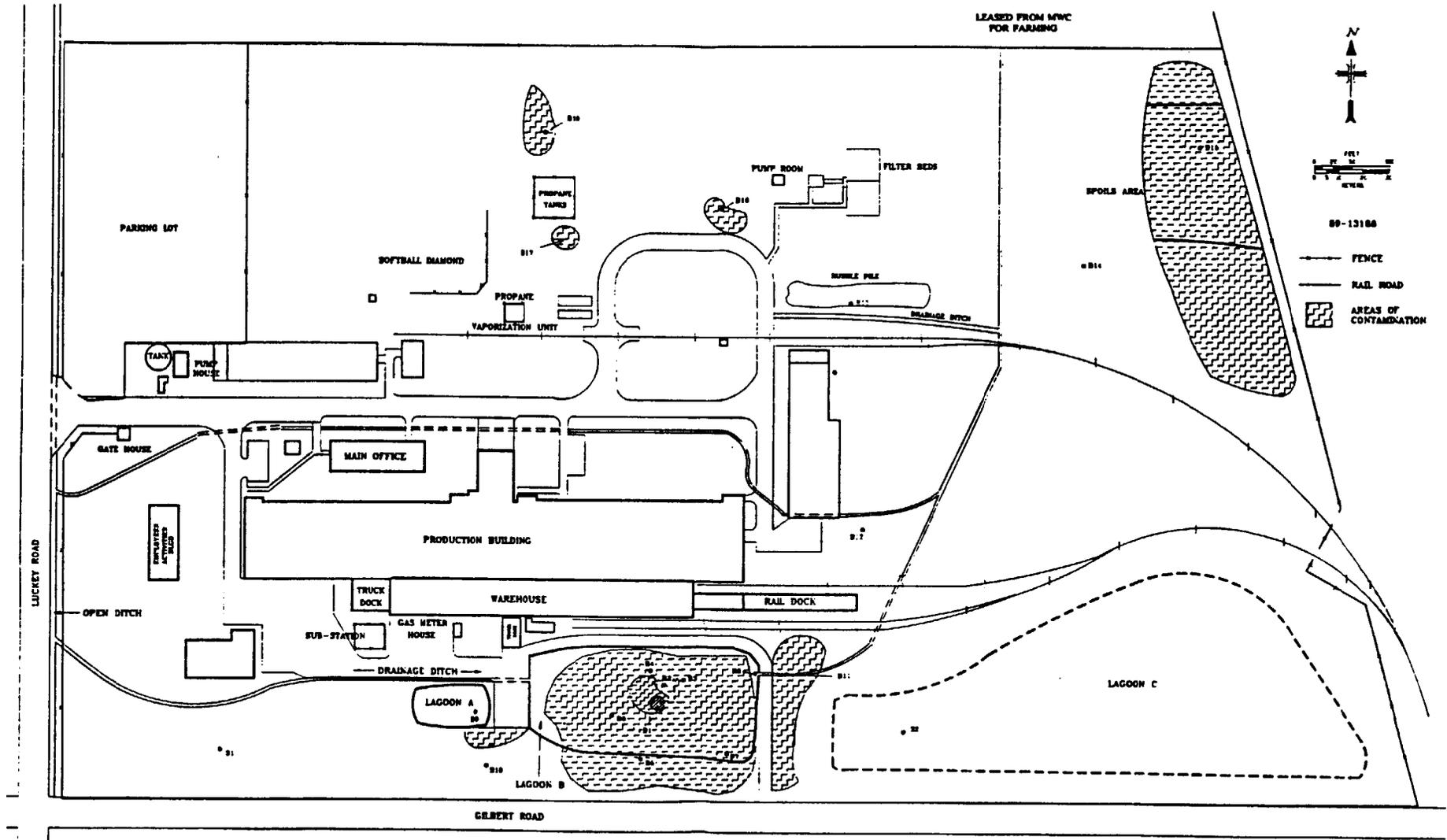


Fig. 2. Locations of soil samples taken at the former Diamond Magnesium Company site, Luckey, Ohio (DML001).



Fig. 3. South side of the former Diamond Magnesium Company site, Luckey, Ohio (DML001), looking west: (December 1988).

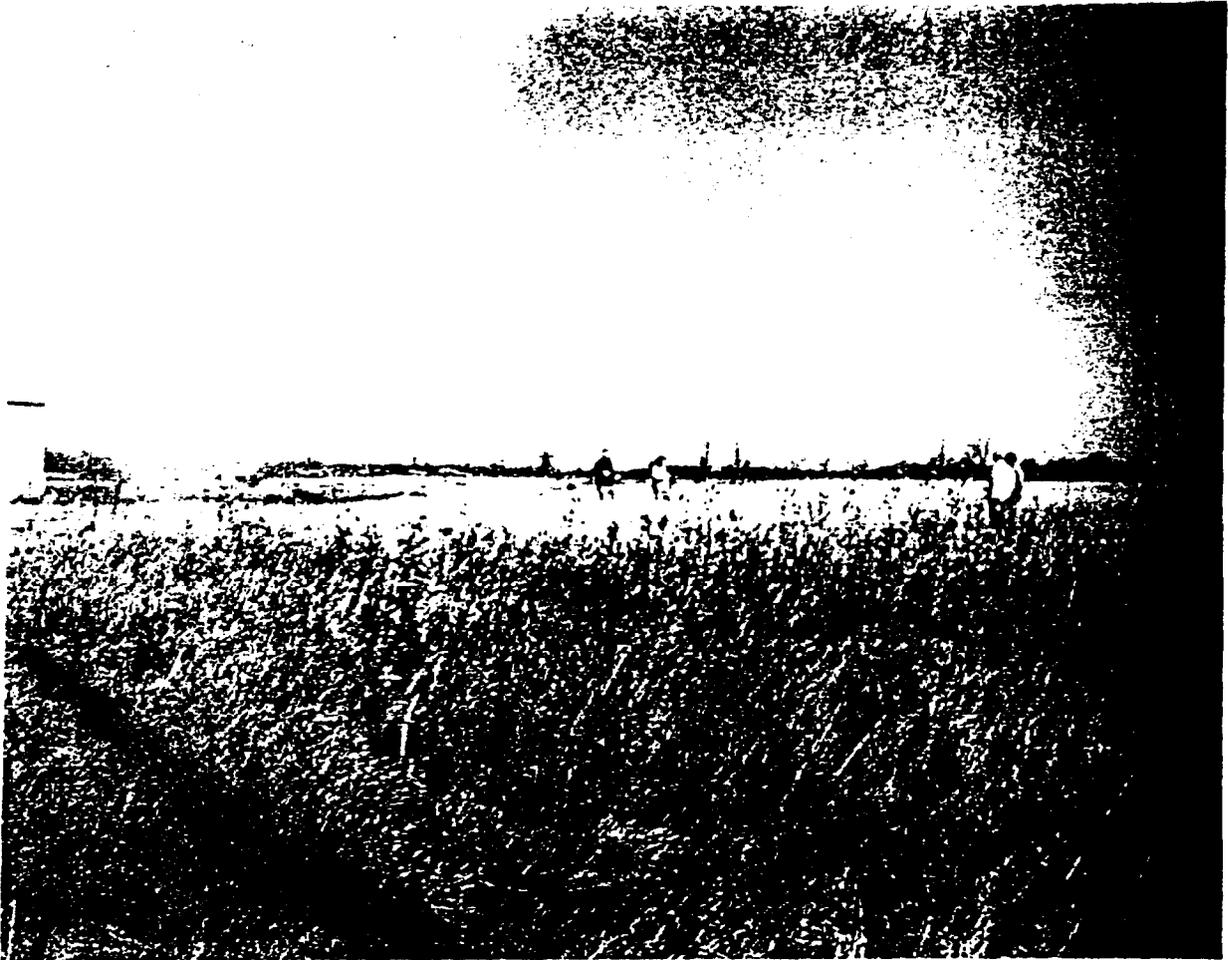


Fig. 4. Lagoon C, looking northeast — the former Diamond Magnesium Company site, Luekey, Ohio (DMI 001) (December 1988).

ORNL-PHOTO 3043-89



Fig. 5. Lagoon B prior to draining, looking west – the former Diamond Magnesium Company site, Luckey, Ohio (DML001).

ORNL-PHOTO 3044-89



Fig. 6. Lagoon B, looking east – the former Diamond Magnesium Company site, Luckey, Ohio (DML001) (December 1988).



Fig. 7. Burial area, northeast corner of the former Diamond Magnesium Company site, Luckey, Ohio (DML001) (December 1988).



Fig. 8. East end of the former Diamond Magnesium Company site, Luckey, Ohio (DML001), looking north (December 1988).

Using a portable gamma scintillation meter, ranges of measurements were recorded for areas of the property surface outdoors. Systematic soil samples were obtained from various locations on the property, irrespective of gamma exposure rates. Biased soil samples were taken at locations with elevated gamma readings. The survey methods followed the basic plan outlined in Reference 3. A comprehensive description of the survey methods and instrumentation is presented in *Procedures Manual for the ORNL Radiological Activities (RASA) Program*.<sup>4</sup>

## SURVEY RESULTS

Applicable federal guidelines are summarized in Table 1. Normal background radiation levels for the Toledo, Ohio, area are presented in Table 2. These data are provided for comparison with survey results presented in this section. All direct measurement results presented in this report are gross readings; background radiation levels have not been subtracted. Similarly, background concentrations have not been subtracted from radionuclide concentrations measured in soil samples.

### Surface Gamma Radiation Levels

Gamma radiation levels measured during a scan of a large portion of the property outdoors are given in Fig. 1. Gamma exposure rates over the major portion of the property ranged from 5 to 9  $\mu\text{R/h}$ . Elevated readings were taken in Lagoons A, B, and C, with the highest measurement (1500  $\mu\text{R/h}$ ) occurring in Lagoon B. (Soil samples B1 and B2 were taken near this location.) Small, isolated, elevated spots (ranging to 800  $\mu\text{R/h}$ ) were found scattered over most of the property. Due to the large number of these spots, not all were sampled. Only the major areas of contaminations are shown on Figs. 1 and 2. On the north side of the property, near the ball field, a cluster of elevated gamma measurements were found. The highest measurement in this area occurred near two propane tanks (800  $\mu\text{R/h}$ ). Spotty areas of elevated gamma measurements appeared to the north and south of the tanks and at an earthen mound near the fence.

### Systematic and Biased Soil Samples

Six systematic and 30 biased soil samples were taken from two systematic locations and 18 biased locations at the former Diamond Magnesium Company site and analyzed for radionuclide concentrations and nonradioactive beryllium concentrations. One biased sample (B19) was taken  $\sim 150$  m ( $\sim 500$  ft) north of the fence shown in the upper right-hand corner of Fig. 2. (This northernmost part of the site, which forms the vertical stem of the L-shape, is not shown on Fig. 2, but is indicated as "leased from MWC.") Results of analysis for  $^{137}\text{Cs}$ ,  $^{226}\text{Ra}$ ,  $^{232}\text{Th}$ ,  $^{238}\text{U}$ , and Be are shown in Table 3. Locations of the systematic (S) and biased (B) samples are shown in Fig. 2. Concentrations of  $^{226}\text{Ra}$ ,  $^{232}\text{Th}$ , and  $^{238}\text{U}$  in the systematic samples ranged from 1.3 to 20 pCi/g, 0.28 to 1.1 pCi/g, and 1.5 to 49 pCi/g, respectively, and concentrations of Be ranged from 6.8 to 5300  $\mu\text{g/g}$ . In the 31 (total) biased soil samples, concentrations of  $^{137}\text{Cs}$ ,  $^{226}\text{Ra}$ ,  $^{232}\text{Th}$ , and  $^{238}\text{U}$

Table 1. Applicable guidelines for protection against radiation

Mode of exposure	Exposure conditions	Guideline value
Radionuclide concentrations in soil <sup>a</sup>	Maximum permissible concentration of the following radionuclides in soil above background levels, averaged over a 100 m <sup>2</sup> area <sup>232</sup> Th <sup>230</sup> Th <sup>228</sup> Ra <sup>226</sup> Ra	5 pCi/g averaged over the first 15 cm of soil below the surface; 15 pCi/g when averaged over 15-cm-thick soil layers more than 15 cm below the surface
Radionuclides in water <sup>b,c</sup>	Maximum permissible concentrations of the following radionuclides in water for unrestricted use <sup>238</sup> U <sup>230</sup> Th <sup>226</sup> Ra <sup>210</sup> Pb	4 × 10 <sup>4</sup> pCi/L 2 × 10 <sup>3</sup> pCi/L 30 pCi/L 100 pCi/L
	Maximum contaminant level combined <sup>226</sup> Ra and <sup>228</sup> Ra in drinking water	5 pCi/L

<sup>a</sup>Adapted from *Guidelines for Residual Radioactive Material at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites*, Rev. 2, U.S. Department of Energy, March 1987.

<sup>b</sup>Nuclear Regulatory Commission, *Standards for Protection Against Radiation*, 10 CFR 20.106, Appendix B, Table II.

<sup>c</sup>EPA-National Primary Drinking Water Regulations (40 CFR 141).

**Table 2. Background radiation levels for the Toledo, Ohio, area**

Type of radiation measurement or sample	Radionuclide concentration (pCi/g)
Concentration of radionuclides in soil	
<sup>226</sup> Ra	0.81
<sup>232</sup> Th	0.80
<sup>238</sup> U	0.76

*Source:* T. E. Myrick, B. A. Berven, and F. F. Haywood, *State Background Radiation Levels: Results of Measurements Taken During 1975-1979*, Oak Ridge National Laboratory, ORNL/TM-7343 (November 1981).

Table 3. Concentration of radionuclides in soil samples taken from the former Diamond Magnesium Company site, Luckey, Ohio (DML001)

Sample No. <sup>a</sup>	Depth (cm)	Radionuclide concentration (pCi/g) <sup>b</sup>				Beryllium ( $\mu\text{g/g}$ )
		<sup>137</sup> Cs	<sup>226</sup> Ra	<sup>232</sup> Th	<sup>238</sup> U	
<i>Systematic samples<sup>c</sup></i>						
S1	0-15	—	1.3 $\pm$ 0.02	0.89 $\pm$ 0.04	1.5 $\pm$ 0.5	6.8
S2A	0-15	—	1.9 $\pm$ 0.07	0.98 $\pm$ 0.03	2.2 $\pm$ 0.2	110
S2B	15-30	—	1.8 $\pm$ 0.04	1.1 $\pm$ 0.06	2.8 $\pm$ 1	60
S2C	30-60	—	17 $\pm$ 0.2	0.72 $\pm$ 0.1	17 $\pm$ 3	1600
S2D	60-90	—	12 $\pm$ 0.1	0.28 $\pm$ 0.08	17 $\pm$ 2	4200
S2E	90-105	—	20 $\pm$ 0.3	<0.34	49 $\pm$ 7	5300
<i>Biased samples<sup>d</sup></i>						
B1A	0-15	—	230 $\pm$ 0.4	<0.33	120 $\pm$ 7	—
B1B	15-30	<0.04	25 $\pm$ 0.1	0.31 $\pm$ 0.08	16 $\pm$ 4	—
B1C	30-45	<0.07	51 $\pm$ 0.2	0.30 $\pm$ 0.1	47 $\pm$ 4	—
B2	0-10	—	150 $\pm$ 0.9	<0.21	78 $\pm$ 3	—
B3	0-15	<0.10	90 $\pm$ 0.3	<0.32	43 $\pm$ 7	—
B4	0-15	<0.06	42 $\pm$ 0.2	0.27 $\pm$ 0.1	29 $\pm$ 3	—
B5A	0-15	0.15 $\pm$ 0.08	54 $\pm$ 0.4	<0.40	53 $\pm$ 1	—
B5B	15-30	<0.08	42 $\pm$ 0.3	<0.28	41 $\pm$ 7	—
B6	0-15	0.08 $\pm$ 0.02	2.1 $\pm$ 0.04	0.93 $\pm$ 0.06	2.6 $\pm$ 0.9	—
B7	0-15	0.79 $\pm$ 0.04	16 $\pm$ 0.08	2.2 $\pm$ 0.08	21 $\pm$ 3	6400
B8	0-15	0.16 $\pm$ 0.08	73 $\pm$ 0.3	<0.34	42 $\pm$ 5	—
B9A	0-15	0.36 $\pm$ 0.04	9.6 $\pm$ 0.2	4.3 $\pm$ 0.2	53 $\pm$ 6	4400
B9B	15-30	0.13 $\pm$ 0.02	7.8 $\pm$ 0.04	1.7 $\pm$ 0.06	52 $\pm$ 5	—
B9C	30-45	<0.06	19 $\pm$ 0.2	1.1 $\pm$ 0.1	61 $\pm$ 10	—
B10A	0-15	0.16 $\pm$ 0.02	8.4 $\pm$ 0.04	0.84 $\pm$ 0.04	11 $\pm$ 0.9	1300
B10B	15-30	0.06 $\pm$ 0.02	2.3 $\pm$ 0.04	1.2 $\pm$ 0.06	2.9 $\pm$ 1	120
B11	0-15	<0.14	70 $\pm$ 0.5	<0.45	24 $\pm$ 6	—
B12	0-15	0.38 $\pm$ 0.1	150 $\pm$ 0.6	<0.62	<27	—
B13A	0-15	0.14 $\pm$ 0.1	100 $\pm$ 0.4	0.99 $\pm$ 0.3	67 $\pm$ 10	1300
B13B	15-30	<0.12	83 $\pm$ 0.4	1.0 $\pm$ 0.2	51 $\pm$ 10	1600
B13C	30-45	<0.09	49 $\pm$ 0.3	1.0 $\pm$ 0.2	27 $\pm$ 4	—
B14A	0-15	0.10 $\pm$ 0.02	12 $\pm$ 0.1	1.4 $\pm$ 0.08	12 $\pm$ 2	—
B14B	15-30	<0.05	15 $\pm$ 0.1	1.3 $\pm$ 0.1	24 $\pm$ 4	—
B14C	30-45	0.08 $\pm$ 0.04	17 $\pm$ 0.1	1.7 $\pm$ 0.1	280 $\pm$ 5	—
B15A	0-15	0.17 $\pm$ 0.1	68 $\pm$ 0.4	<0.41	73 $\pm$ 7	—
B15B	15-30	<0.16	63 $\pm$ 0.5	<0.53	59 $\pm$ 8	—
B15C	30-45	<0.12	59 $\pm$ 0.4	0.63 $\pm$ 0.3	51 $\pm$ 10	—
B16	0-15	—	760 $\pm$ 2	<1.6	250 $\pm$ 20	—
B17	0-15	—	4000 $\pm$ 3	<3.5	<98	310

Table 3 (continued)

Sample No. <sup>a</sup>	Depth (cm)	Radionuclide concentration (pCi/g) <sup>b</sup>				Beryllium ( $\mu\text{g/g}$ )
		<sup>137</sup> Cs	<sup>226</sup> Ra	<sup>232</sup> Th	<sup>238</sup> U	
<i>Biased samples<sup>d</sup></i>						
B18	0-15	—	230 $\pm$ 1	<1.0	160 $\pm$ 20	—
B19	0-6	0.77 $\pm$ 0.02	11 $\pm$ 0.04	0.95 $\pm$ 0.04	12 $\pm$ 2	3500

<sup>a</sup>Location of soil samples are shown on Fig. 2.

<sup>b</sup>Indicated counting error is at the 95% confidence level ( $\pm 2\sigma$ ).

<sup>c</sup>Systematic samples are taken at locations irrespective of gamma exposure.

<sup>d</sup>Biased samples are taken from areas shown to have elevated gamma exposure rates.

ranged from <0.04 to 0.79 pCi/g, 2.1 to 4000 pCi/g, <0.21 to 4.3 pCi/g, and 2.6 to 280 pCi/g, respectively. Concentrations of Be ranged from 120 to 6400  $\mu\text{g/g}$ . Five samples were taken from systematic soil sample location S2, to a depth of  $\sim 105$  cm (42 in.). Concentrations of  $^{226}\text{Ra}$  and  $^{232}\text{Th}$  (in pCi/g) are shown graphically in Fig. 9, and concentrations of Be (in  $\mu\text{g/g}$ ) are shown in Fig. 10. Almost all of the biased soil samples were above DOE guidelines for  $^{226}\text{Ra}$  concentrations in surface and subsurface soil (Table 1), with the highest concentration (4000 pCi/g) occurring in sample B17. Although specific guidelines are not given for concentrations of Be, values from the 14 soil samples analyzed for Be appear high. Beryllium constitutes about 0.005% of the earth's crust and is about thirty-second in order of abundance of elements. Average concentration of Be in soil ranges from 0.13 to 0.88  $\mu\text{g/g}$ , and it occurs in concentrations approximating those of Cs, Sc, and As.<sup>5</sup>

### Water Samples

Three water samples were taken from three locations at the former Diamond Magnesium Company site. Sample W1 consisted of potable water taken from the plant's main office building; sample W2 represented raw well water from the wellhead of the west well, and sample W3 was surface groundwater taken 6.4 m (21 ft) west of biased soil sample B13, in a contaminated area. Results of analysis of water samples are given in Table 4. The water samples were analyzed for concentrations of six radionuclides. This analysis showed determinable values for three isotopes:  $^{226}\text{Ra}$  in sample W3 (26 pCi/L);  $^{232}\text{Th}$  in samples W1 and W3 (0.014 and 0.086 pCi/L, respectively), and  $^{238}\text{U}$  in samples W1, W2, and W3 (1.4, 3.5, and 110 pCi/L, respectively). Permissible concentrations for radionuclides in water for unrestricted use are given in Table 1.

### SIGNIFICANCE OF FINDINGS

Measurements of gamma radiation levels and results of soil sample analysis from the former Diamond Magnesium Company site indicate that the property contained radioactive contamination from  $^{226}\text{Ra}$  and  $^{238}\text{U}$  and excessive concentrations of Be. Because waste solutions and precipitated sludges from the beryllium processing operations were impounded in the lagoons on the south side of the plant, concentrations of beryllium would be expected to be high at these locations (soil sampling locations B7, B9, and B10). However, the data suggest that these high beryllium concentrations are more widespread than expected, as evidenced by the results of soil samples taken on the north side of the plant (soil sampling locations B13 and B17), and extending onto the leased property north of this site, soil sample B19 (3500  $\mu\text{g/g}$ ).

The concentration and extent of  $^{226}\text{Ra}$  are in excess of applicable DOE guidelines (Table 1). These concentrations were found at 18 of the 19 biased soil samples locations shown on Fig. 2. Based on the results of this radiological assessment, it is recommended that a follow-up, detailed radiological survey of both surface and subsurface environs be performed to more precisely define the extent of the contamination.

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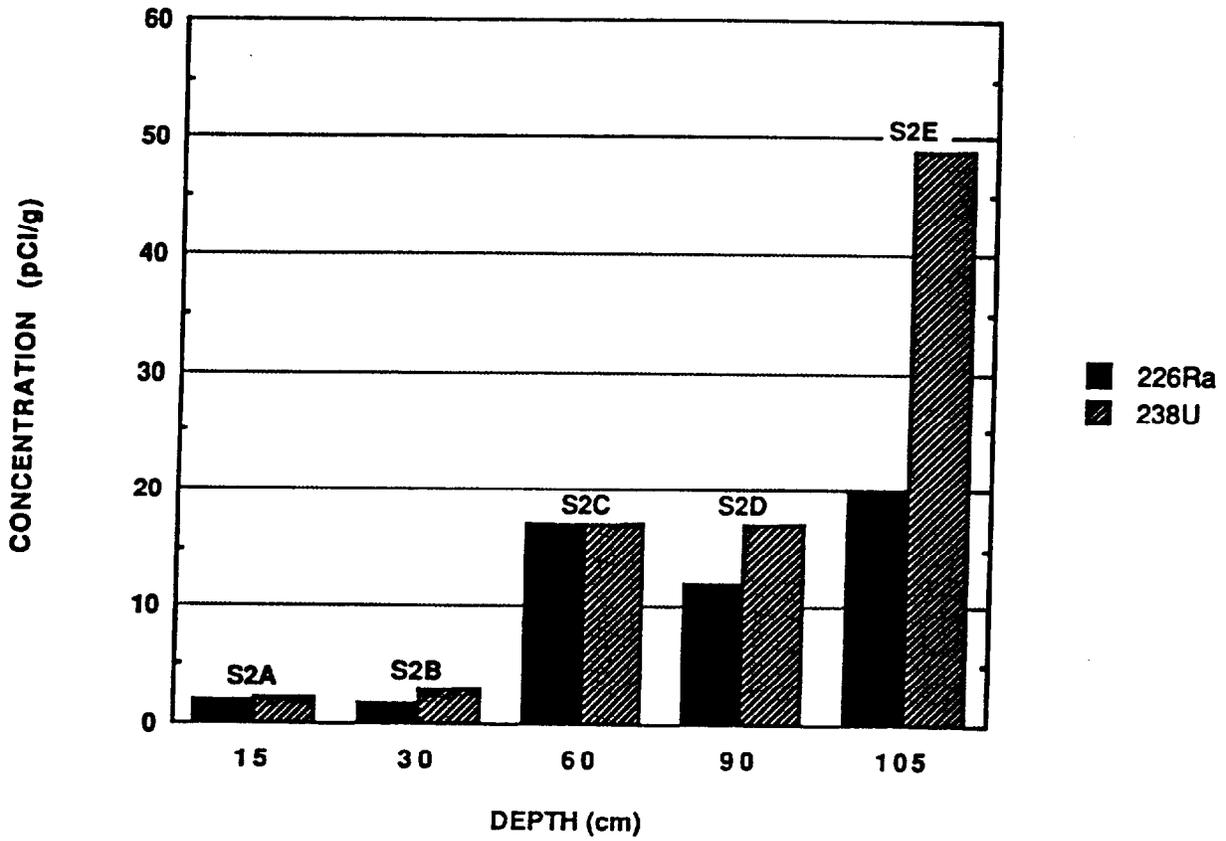


Fig. 9. Radionuclide concentrations (pCi/g) in soil sample S2, taken from the former Diamond Magnesium Company site, Luckey, Ohio (DML001).

ORNL-DWG 89-10907

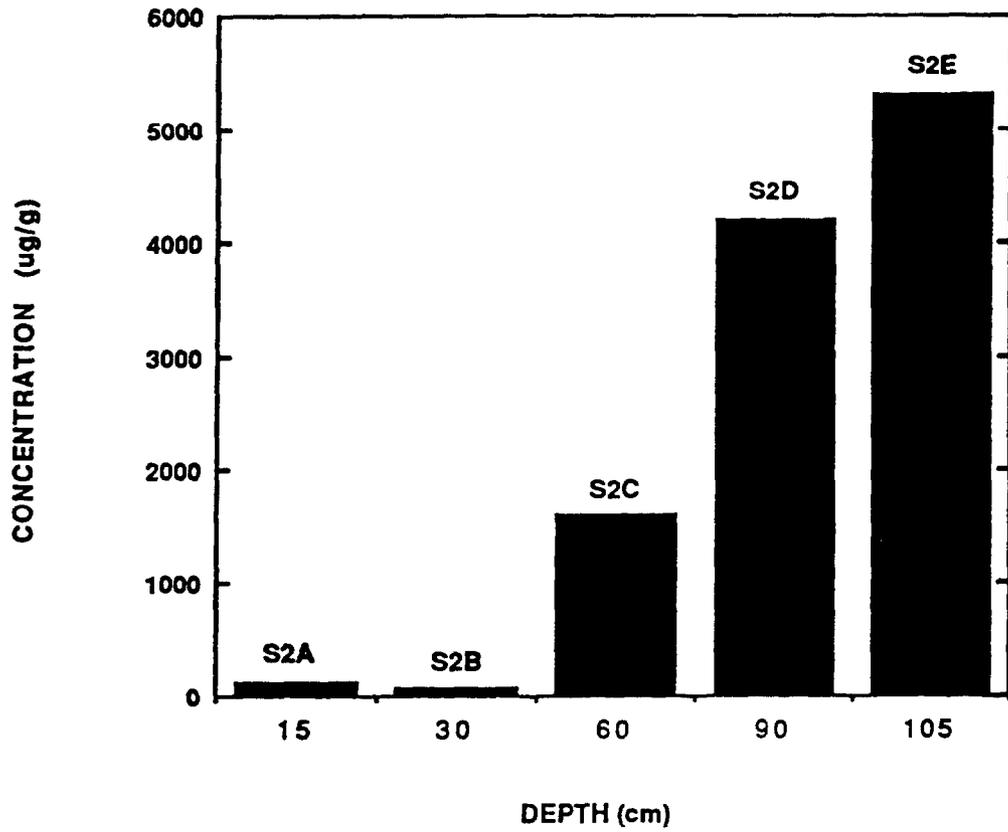


Fig. 10. Beryllium concentrations ( $\mu\text{g/g}$ ) in soil sample S2, taken from the former Diamond Magnesium Company site, Luckey, Ohio (DML001).

**Table 4. Radionuclide concentrations in water samples from the former Diamond Magnesium Company site, Luckey, Ohio (DML001)**

Sample No.	Radionuclide concentration (pCi/L)					
	<sup>7</sup> Be	<sup>60</sup> Co	<sup>137</sup> Cs	<sup>226</sup> Ra	<sup>232</sup> Th	<sup>238</sup> U
W1	<54	<8.1	<8.1	<0.27	0.014 ± 0.02	1.4 ± 0.2
W2	<54	<8.1	<8.1	<0.27	<0.014	3.5 ± 0.3
W3	<54	<5.4	<5.4	26 ± 7	0.086 ± 0.07	110 ± 3

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